An 18-month journey to TurtleBot 4
Part 1: Why TurtleBot 4?

A long history between Open Robotics/Willow Garage and Clearpath

TRADEMARK LICENSE AGREEMENT

The TRADEMARK LICENSE AGREEMENT (the “Agreement”) is made and entered into as of the date last below written (the “Effective Date”) by and between Willow Garage Inc. LICENSOR, a corporation organized under the laws of the State of California (“Licensor”), and LICENSEE, a corporation organized under the laws of (“Licensee”).

RECITALS

WHEREAS, Licensor owns the mark(s) “TurtleBot” in connection with electronic components and devices, including but not limited to robots, robotic systems, and computer hardware and ROS software (the “Licensed Marks”).

Purchase Order

Order #: PO-13112
Order Date: 09/07/2011
Ship Via: FedEx Ground - 43717683
Requestor: Tashara Brown / TBPR020

Return to:
Clearpath Robotics
121 Charles St. W., Suite 330
Kitchener, Ontario N2G 1H6
Canada

Clearpath Robotics Inc. ©2022
Part 1: Why TurtleBot 4?

A long history between Open Robotics/Willow Garage and Clearpath
Part 1: Why TurtleBot 4?

Welcome to the Family...
Part 1: Why TurtleBot 4?

Establishing a Vision

- Good Value
- SLAM Out of the Box
- ROS2
- Sleek Product Design
- User Focused
Part 1: Why TurtleBot 4?

Establishing a vision
Part 1: Why TurtleBot 4?

Need for Partnerships
Part 1: Why TurtleBot 4?

Need for Partnerships

Luxonis
Part 1: Why TurtleBot 4?

Need for Partnerships
Part 1: Why TurtleBot 4?

Need for Partnerships

Raspberry Pi
Part 2: Requirements and design

The Plan

**SCHEDULE**
- Project start in 2021
- Quick launch to market to maximize excitement for ROS2 and TurtleBot refresh
- Aim for 2022

**DESIGN**
- Strive to Wow everyone
- Design a sellable product

**COST**
- Reduce Cost & Increase Value where possible
- Make robotics entry affordable

**REGULATORY CONSTRAINTS**
- Comply with North American Standards
Part 2: Requirements and design

TurtleBot 4 vs. Previous TurtleBots

Goals for TurtleBot 4

Provide more Value
Polished Product Design
Exceed previous generation features
# Part 2: Requirements and design

## TurtleBot 4 vs. Previous TurtleBots

<table>
<thead>
<tr>
<th></th>
<th>TurtleBot 3 (Waffle)</th>
<th>TurtleBot 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onboard Computer</td>
<td>Raspberry Pi 4B*</td>
<td>Raspberry Pi 4B</td>
</tr>
<tr>
<td></td>
<td>4GB RAM</td>
<td>4GB RAM</td>
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<tr>
<td></td>
<td>1.5GHZ Quad Core CPU</td>
<td>1.5GHZ Quad Core CPU</td>
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<tr>
<td>Vision</td>
<td>Raspberry Pi Camera V2*</td>
<td>Luxonis Oak-D Pro</td>
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<tr>
<td></td>
<td>RGB</td>
<td>RGB Stereo Pair</td>
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<tr>
<td></td>
<td>8MP</td>
<td>12MP</td>
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<tr>
<td></td>
<td>30FPS</td>
<td>120FPS</td>
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<tr>
<td>LIDAR</td>
<td>LDS-01 - 360°</td>
<td>RPLIDAR A1M8 - 360°</td>
</tr>
<tr>
<td>Battery Run Time</td>
<td>~2 Hours</td>
<td>2.5+ Hours</td>
</tr>
<tr>
<td>UI with Display</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Preassembled for Quick Start</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Easy Expansion with USB-C</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Gazebo</td>
<td>Classic</td>
<td>Ignition</td>
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<tr>
<td>Price</td>
<td>$1681</td>
<td>$1899</td>
</tr>
</tbody>
</table>

*https://www.robotis.us/turtlebot-3/
Part 2: Requirements and design

The First commercially available robot developed for ROS2
Part 2: Requirements and design

Committing to Gazebo (Ignition)
Part 2: Requirements and design

Open Source
Part 3: Pandemic Driven Development

Test & engineering remotely

**Keys to Success**

- Regular Team Meetings (Virtual, Phone, In Person Distanced)
- Progress Reviews (Design Iterations, Software Development)
- Resource Coordination
- Support in Times of Need
Part 3: Pandemic Driven Development

Restrictions Started to Ease During Testing

- Weighted Ramp Climb
- Battery Life Testing
- Board Inspection and Testing
- EMC Testing
Part 3: Pandemic Driven Development

Impacts of supply chain - A Vicious Cycle

- Shortage Impact - Component Sold Out
  - Search for Alternative Component
  - Decide on Available Component
  - Implement in Design
Raspberry Pi Shortage

“As you will have noticed, it can be hard to buy a Raspberry Pi unit from stock at the moment.”

- Eben Upton, CEO of Raspberry Pi Ltd.
  April 2022

CLEARPATH’S STRATEGY

- Order from Resellers for Initial Build
- Order for future builds well in advance (I.E. ASAP!)
Part 3: Pandemic Driven Development

Managing and Mitigating Uncertainty

- Complete Design
- Plan Build Secure Component Stock
- Review Costs and Timeline
- Launch Announcement
Part 4: Initial Successes

Clearpath Robotics TurtleBot4 Hack Day
User Following
Part 4: Initial Successes

Clearpath Robotics TurtleBot4 Hack Day

NED 2
Manipulator Integration
Part 4: Initial Successes

TurtleBot4 is currently shipping to customers, so more exciting stories are to come!
Part 4: Initial Successes

Q&A